



# High Mountain *Lakes and Streams*



Stephen Ingram

## of the **Sierra Nevada**

*a guide to the aquatic ecosystems*



## *New perspectives on management*

You may be among the thousands of people who venture into the backcountry of the Sierra Nevada. No doubt, you're attracted to the stunning alpine scenery, the miles of wilderness trails, and the multitude of clear lakes that make the region so inviting.

There are more than 4,000 lakes and 11,000 miles of streams in the high Sierra, most located on federal lands managed by the National Park Service and the U. S. Forest Service. Many people who visit the high Sierra also enjoy fishing in these waters. Whether you've come here to fish or not, you may not be aware that nearly all of the lakes above 6,000 feet in this region were originally fishless. Many have been stocked with trout for more than 100 years.

While stocking has increased recreational fishing opportunities, recent studies indicate that it has also had a negative effect on species native to Sierra lakes and streams. As a result of these findings, the agencies involved in managing high elevation resources are working together to review management policies and fish stocking practices in the Sierra Nevada.

This news has sparked the interest of many backcountry visitors who are concerned about protecting native species. Others are eager to know how revised stocking practices might impact fishing. If you're among them, we would like to assure you that we can protect native species and still maintain recreational fishing opportunities in the Sierra Nevada.

We prepared this publication to help you understand the ecology of the Sierra Nevada lakes, the history and long-term effects of past management practices in the region, and the complex issues which resource management agencies now face.

## *Who manages the resources?*

Most of the high elevation lands within the Sierra Nevada are federal lands administered by the U. S. Forest Service or the National Park Service. These agencies, along with the California Department of Fish and Game, are responsible for managing fish and wildlife resources in this region. The two federal agencies have different mandates. As a result, some management regulations and objectives on national forest and national park lands may differ.

There are 3.5 million acres of designated wilderness within the Sierra Nevada, including much of the higher elevations along the Sierra Crest. The Wilderness Act provides for special protection of lands designated as wilderness. These areas are to be managed to allow natural forces to operate freely, and to provide recreation in a way that preserves wilderness for future generations. Both the National Park Service and the Forest Service manage designated wilderness areas in the Sierra to meet the direction and intent of the Wilderness Act.

In passing the Wilderness Act, some exceptions were made to the wilderness ideal, such as a provision that permits livestock grazing to continue where it was established at the time of designation. The Act also recognizes the responsibilities states have in managing fish and wildlife resources in designated wilderness areas. Fish stocking is one of the state's responsibilities.



**National Park Service (NPS)** National parks were established to preserve natural resources and to provide recreational enjoyment of park lands. The National Parks Act of 1916 includes specific direction to protect wildlife in an unimpaired state within parks. While fishing is allowed, fish stocking, hunting and livestock grazing are no longer practiced in national parks in the Sierra.

**U. S. Forest Service (USFS)** National forests were established by the Organic Act of 1897 to provide timber, livestock forage and watershed protection. Subsequent legislation has broadened the agency's mission to include the protection of resources and provision of recreational opportunities. Managing these multiple uses has been a key concept for this agency.

**California Department of Fish and Game (CDFG)** The CDFG implements the policies of the State Fish and Game Commission and is the public trustee for California fish and wildlife resources. The CDFG manages California's fish, wildlife and plant resources for their ecological values and for public recreation, including fishing. On national forest lands, the department manages fish and wildlife resources in coordination with the USFS, and in an advisory role with the NPS in national parks.



The Sierra Nevada stretches 360 miles along the eastern side of California. The lakes and streams described in this publication lie in the upper montane, subalpine and alpine life zones, between 6,000 and 13,000 feet elevations. *Sierra Nevada Ecosystem Project (SNEP) Report*



Glaciation has shaped the high Sierra Landscape.

## *How did the Sierra lakes form?*

Geology and climate shaped the high mountain lakes of the Sierra Nevada. During the Pleistocene Age, from two million to

10,000 years ago, glaciers periodically covered the high country. They carved out cirque valleys and shallow basins that would later fill with snowmelt to become the lakes you see today. These relatively recent periods of glaciation scoured soils and removed plants and animals that existed in the high country before the glaciers occurred. Glacial scouring also created steep stream gradients and hanging valleys with waterfalls – conditions that prevented fish from colonizing most lakes and streams after the glaciers receded.

Due to glacial scouring and a harsh climate, most soils in the high Sierra are thin and nutrient-poor. As a result, most of the lakes are also nutrient-poor. At the highest elevations, low winter temperatures cause the smaller, shallower lakes to freeze solid. Large lakes freeze on the surface and are covered by a thick blanket of snow until early summer.

## *What species are native to these lakes and streams?*

With few exceptions, the high mountain lakes and streams above 6,000 feet were historically fishless-dominated instead by amphibians, insects and other aquatic invertebrates.



Stephen Ingram

Second-year mountain yellow-legged tadpole with partially developed rear legs.

## *Mountain yellow-legged frog and other amphibians*

Among the amphibians found in high Sierra lakes and streams is the mountain yellow-legged frog—a highly aquatic frog that lives in lakes, meadow streams and isolated ponds.



Stephen Ingram

Gable Lakes Basin (John Muir Wilderness), where riparian plants only have a 3-5 month growing season





The Yosemite toad (*Bufo canorus*) lives in mountain meadows, from the Tahoe area to south of Kaiser Pass. Adult toads are primarily terrestrial, but breed in lakes and ponds soon after the snow melts.

This unique amphibian is found only in the higher elevations of the Sierra Nevada and a few locations in Southern California. In most frog species, the tadpole stage typically lasts only a few weeks or months. But tadpoles of the mountain yellow-legged

frog need two to three years to develop. This species depends on a diversity of aquatic habitats, including lakes, ponds and streams that don't freeze solid in winter or dry up in summer. The adult frogs are seldom found more than a few jumps from water.



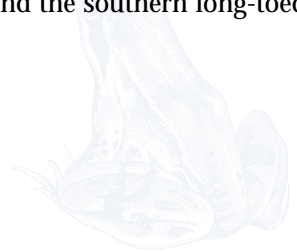
Partially thawed unnamed lake in Dusy Basin, Kings Canyon National Park

Between 1914 and 1916, Zoologist Dr. Joseph Grinnell surveyed animals in the Yosemite area, and took particular notice of the mountain yellow-legged frog. "This species," he wrote in his book *Animal Life of the Yosemite Region*, "is the commonest amphibian in most parts of the Yosemite section, and is most likely to come to the attention of fishermen and others who may walk along the banks of Sierra streams and lakes."

Other amphibians found in the high Sierra include the Pacific tree frog—which does not appear to be declining in most areas—as well as the Yosemite toad, the Western toad (also called California toad) and the southern long-toed salamander.



Adult mountain yellow-legged frog (*Rana muscosa*)



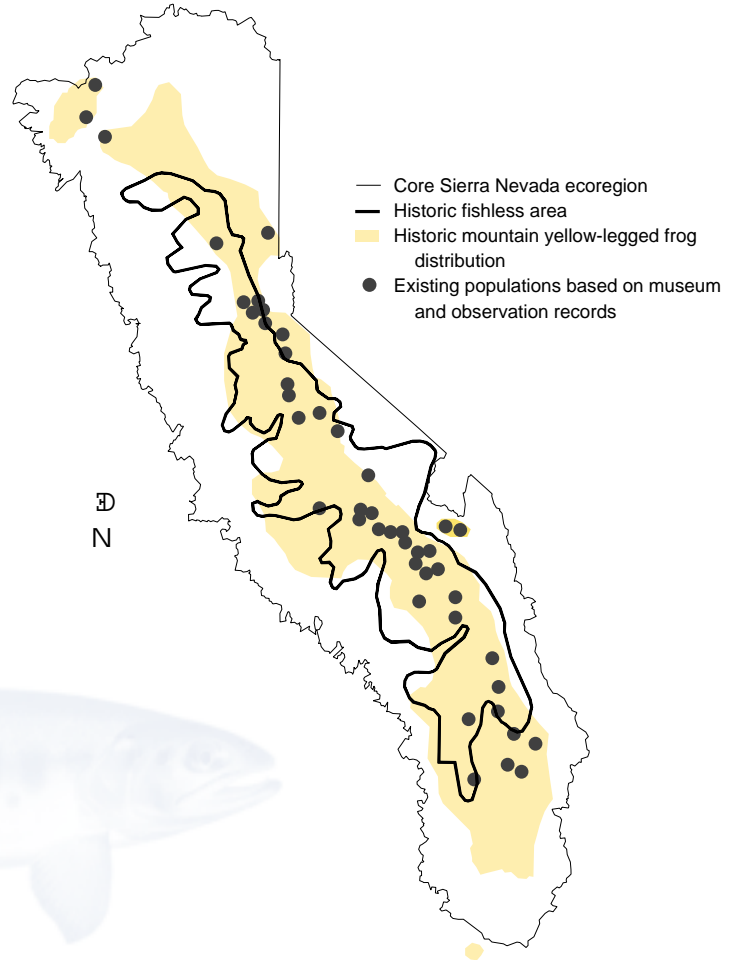


A pair of native California golden trout (*Oncorhynchus mykiss aquabonita*) spawning

### **Native fishes**

The high elevation aquatic ecosystems of the Sierra, and the organisms within them, evolved and developed largely in the absence of fish. Only about 20 lakes above 6,000 feet naturally contained trout (i.e., Tahoe, Donner, Independence and Twin Lakes). These lakes were all connected to streams that did not have impassable barriers and also had populations of native fish. Rainbow trout are native to the west slope Sierra stream systems at lower elevations, but for the most part did not naturally occur in the lakes and streams of the high Sierra.

There were exceptions. Although large expanses of the high Sierra Nevada were glaciated during the Pleistocene, this was not true of the high elevations of the Kern River Plateau, in the southern part of the range. Several species of native trout (Little Kern golden, Kern River rainbow and Cali-



The historic fishless area of the Sierra Nevada and the historic distribution of mountain yellow-legged frog coincide with the extent of most recent glaciation in the range.  
Sierra Nevada Ecosystem Project (SNEP) Report

fornia golden) evolved along the main stem and tributaries of the upper Kern drainage to elevations of 9,800 feet.

On the east side of the range, there were also a few high elevation streams that were passable to fish due to gentler topography than is usual of the steep east-side of the range. Lahontan cutthroat trout inhabited streams up to 8,000 feet in the Carson, Walker and Truckee River drainages, and Paiute cutthroat trout reached 8,200 feet up the Carson River. Other native fish species found in east-side high Sierra streams include Paiute sculpin, Tahoe and mountain sucker, speckled dace, mountain whitefish and Lahontan redbreast.

### ***Zooplankton***

The zooplankton community found in high Sierra lakes consists of semi-transparent microcrustaceans that range in size from microscopic to two millimeters. Factors such as elevation, lake size, type of bedrock and nutrient levels determine which zooplankton are found in any particular lake. Many zooplankton species forage on algae, the base of the lake food web, and thus help maintain water clarity. Zooplankton are a food source for aquatic insects and fish. Trout feed selectively on large-bodied zooplankton, which have become rare in most lakes with fish.

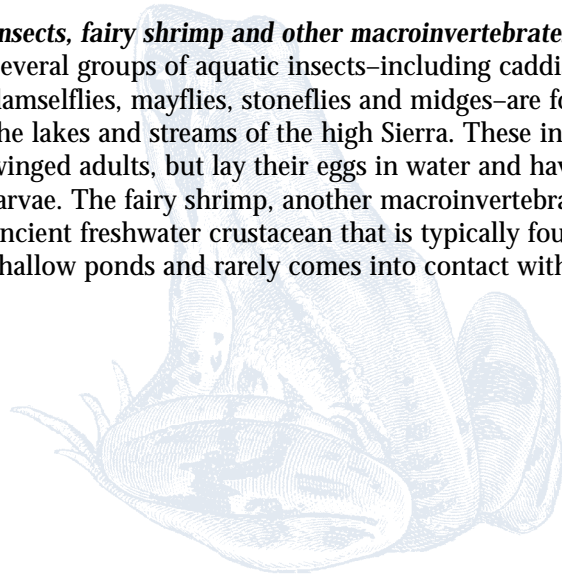


Ralph Cutter

Fairy shrimp swim upside down, using leaf-like legs for locomotion and feeding.

### ***Insects, fairy shrimp and other macroinvertebrates***

Several groups of aquatic insects—including caddisflies, damselflies, mayflies, stoneflies and midges—are found in the lakes and streams of the high Sierra. These insects have winged adults, but lay their eggs in water and have aquatic larvae. The fairy shrimp, another macroinvertebrate, is an ancient freshwater crustacean that is typically found in shallow ponds and rarely comes into contact with fish.







The California Fish and Game Commission's 20-mule team packing golden trout over Paiute Pass, 1914

## ***What's the history of fish stocking in the Sierra?***

Native Americans crossed the high Sierra to trade goods and hunt large game animals. Although there were no permanent settlements at high elevations, summer campsites were prevalent throughout the range. Native Americans caught trout where the fish occurred naturally, but there is no evidence that they transferred fish from their native waters.

### ***When the West was young***

Sheep herders, miners and other Euro-American settlers who moved westward in the mid-1800s were California's first fish stockers. They moved native trout, which they used as a food source, into fishless drainages and areas upstream of waterfalls.

Beginning in the 1860s, sportsmen's groups, the Sierra Club, the U.S. Army, the California Fish Commission and

individual outdoorsmen introduced trout into fishless streams and lakes throughout the Sierra Nevada to increase recreational fishing opportunities.

In 1876, for example, Colonel Sherman Stevens transferred 12 golden trout from Mulkey Creek to fishless Cottonwood Creek by carrying them 4 miles in a coffee pot. About 15 years later, E.H. Edwards and others took 50 golden trout from Cottonwood Creek and transported them upstream, beyond impassable barriers, to the fishless Cottonwood Lakes. These trout populations have been used since 1918 as the source for golden trout fingerlings stocked throughout the state.

Among the non-native introductions were brook trout from the eastern United States and brown trout from continental Europe and Scotland. The noted Sierra mountaineer Norman Clyde is said to have introduced brook trout into hundreds of lakes.



### ***Into the 20th century***

In 1909, the California Fish and Game Commission assumed responsibility for fish stocking. As non-native trout became established in the high Sierra, the state systematically used pack animals to move trout to new lakes and streams. Beginning in the 1950s, aerial stocking by CDFG provided a lower cost alternative to packing in fish, making it possible to stock very remote lakes and expand the stocking program.

The National Park Service began phasing out stocking in 1969. Though the policy to end stocking in national parks became official in 1975, limited stocking occurred in both Yosemite and Sequoia/Kings Canyon National Parks until 1991. Fish stocking is still permitted in national forests, with the exception of wilderness lakes that were not stocked prior to an area's designation as wilderness. As a result of past introductions, 85 percent of lakes within the national forests and half of the lakes in national parks of



Roger Bloom

Brook trout (*Salvelinus fontinalis*), top, is a native to eastern North America and is one of the most common trout species introduced to the Sierra Nevada. Because they spawn in both lakes and streams, once planted they are difficult to eliminate. Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*), bottom, is native to the Sierra Nevada which has been out-competed in its range by introduced non-native trout.

the high Sierra that are large and deep enough to support fish now contain trout.

Brook, golden, and rainbow trout are the most common species in high Sierra lakes, while brown, cutthroat and lake trout were planted in fewer lakes. Today fingerling trout are stocked in lakes where they can survive and grow to a catchable size.

### ***What's the trade-off of fish stocking?***

While the introduction of trout into the fishless lakes of the high Sierra has greatly expanded fishing opportunities, these introductions have come at a price. In the nutrient-poor, high elevation lakes, trout are the top predators—consuming zooplankton, aquatic insects, crustaceans and tadpoles. Non-native trout have caused certain native amphibian and fish populations to decline.

#### ***The biological price***

The records of early 20th century naturalists indicate that mountain yellow-legged frogs were present in most Sierra lakes between 8,000 and 12,000 feet. Zoologist Joseph Grinnell, who reported in 1915 that the frogs were prevalent throughout the Yosemite region, also observed that “. . . [mountain yellow-legged] frogs, in tadpole form at least, do not occur in lakes which are stocked with trout. . . the advent of fish in a lake sooner or later nearly or quite eliminates the frogs.”

Scientists surveying the same area in 1994 found mountain yellow-legged frogs in only 15 percent of the locations where Grinnell had recorded sightings in 1915. The fact that frogs and trout are seldom found in the same lakes is believed to be the result of trout predation on mountain



Stephen Ingram

Today, aircraft are used to stock fingerlings, which survive the air drop.

yellow-legged tadpoles. Because the tadpoles inhabit the same waters suitable for stocked trout for such an unusually long metamorphosis period, they are particularly vulnerable to trout predation. Many of the lakes necessary to maintain viable frog populations are now inhabited by trout.

The status of native trout in high Sierra streams is also threatened by past stocking practices, both legal and illegal. Lahontan cutthroat, Paiute cutthroat and Little Kern golden trout are all federally-listed threatened species. Introduced brook and brown trout have out-competed native trout in many streams. Introduced rainbow trout have hybridized with cutthroat and golden trout to the extent that only a few genetically pure populations remain. The Department of Fish and Game and the Forest Service

have worked cooperatively to successfully restore several pure populations.

In addition to the effects on specific species, the introduction of non-native species has other subtle impacts on ecosystem structure and dynamics. It can disturb predator-prey relationships and alter nutrient cycles. Effects may extend into surrounding terrestrial habitat. Predation by trout on zooplankton and macroinvertebrates can alter the aquatic food chain and may affect associated species, such as birds and bats that feed on water-hatched insects. Researchers are also looking at what effect the decline in mountain yellow-legged frogs may be having on its natural predators, such as the western terrestrial garter snake.

### ***The benefits of recreational fishing***

Thousands of people like you enjoy all kinds of recreation activities in the high Sierra each summer including backpacking, hiking, horse packing, wildflower viewing, rock climbing and fishing. Research indicates that 25 to 40 percent of wilderness users do some fishing on their back-country trips, though it may not be a primary reason for their trip. For some of these folks, fishing is the primary reason for their trip. Anglers enjoy the challenge, relaxation or chance to catch a fresh meal that fishing provides.

All recreational activities, including fishing, contribute to California's growing recreation and tourism industry. When you hire an outfitter or guide, buy equipment, food, lodging and other services, you're helping to support the economies of local communities. Additionally, the sale of fishing licenses generates revenue for the state, which is then used to manage fish and wildlife resources.



Grazing cattle and streambank impacts along the South Fork of the Kern River, Golden Trout Wilderness

## What are the impacts of other uses of the high Sierra?

### Livestock grazing

The Gold Rush lured new settlers to California, and many brought livestock with them. Beginning in the 1850s, the Sierra was exposed to the unregulated grazing of millions of sheep and cattle. By 1900 many meadows showed signs of overgrazing, as did riparian areas along stream banks. In

some locations, the impacts of this historic overgrazing persist today.

The number of livestock grazed dropped significantly after the 19th century and has continued to decline throughout the 20th century. While current management practices have greatly reduced the damage caused by livestock in most areas, grazing continues to negatively impact aquatic habitats and native species in a number of high Sierra locations.

### Recreation use

Recreational use of the high Sierra escalated with the creation of national parks, the designation of wilderness areas in the 1960s, and increased interest in backpacking and the natural environment in the 1970s. Signs of overuse in backcountry campsites were reported as early as 1933.

Today visitor education on backcountry use—and regulations such as limits on numbers of visitors, length of stay and the use of campfires—help control impacts. However, camping and hiking still cause a loss of vegetation and compacted soils along lake shorelines. Improper disposal of human and recreational packstock waste have caused the spread of giardia and other pathogens in high Sierra waters.

Practicing “Leave No Trace” techniques in the backcountry helps reduce these impacts.



Jim Michaeals

User trails crisscross a meadow near Round Top Lake (Mokelumne Wilderness), a typical sign of heavy use seen at popular Sierra lakes.





Researcher with a gill net measuring trout at Long Lake, Emigrant Wilderness.

## *What's the latest research on amphibian declines?*

Scientists are conducting research in the high Sierra to learn more about the ecosystems of high elevation lakes, and the interactions of species that may affect declining amphibian populations.

One project is comparing the fauna of approximately 1000 high elevation lakes in Kings Canyon National Park with 1000 lakes in the adjoining John Muir Wilderness. The two areas have similar latitude, elevation and location on the west slope and crest of the Sierra, but fish stocking patterns have differed substantially. In the John Muir Wilderness, 80 percent of the larger lakes contain trout. In Kings

Canyon, where fish stocking was much less intensive and then phased out beginning in the 1970s, only 40 percent of such lakes now contain trout.

Researchers have found that 35 percent of the lakes in Kings Canyon National Park have populations of mountain yellow-legged frogs, compared to only 5 percent in the John Muir Wilderness. The less intensive fish stocking in Kings Canyon National Park, and the termination of the practice in the late 1970s, has resulted in a number of fishless lakes, some of which are now available as refuges for the frogs.

Another finding of this study indicates that most of the lakes which are currently stocked in the John Muir Wilderness have self-sustaining trout populations. Even if fish stocking were stopped, while some lakes would become fishless, many lakes would continue to support healthy trout populations and provide good fishing opportunities. A reduction in stocking would be beneficial to native species, particularly the mountain yellow-legged frog.

Research projects in the Sierra are also investigating other potential factors in amphibian declines including pesticide drift from the San Joaquin Valley, introduced and native diseases, and increased nitrification due to fertilizers and pollutants from automobile emissions. To date, no clear evidence links the declines to these other factors, though research continues. Concerns about world-wide declines of amphibians have intensified many research efforts.



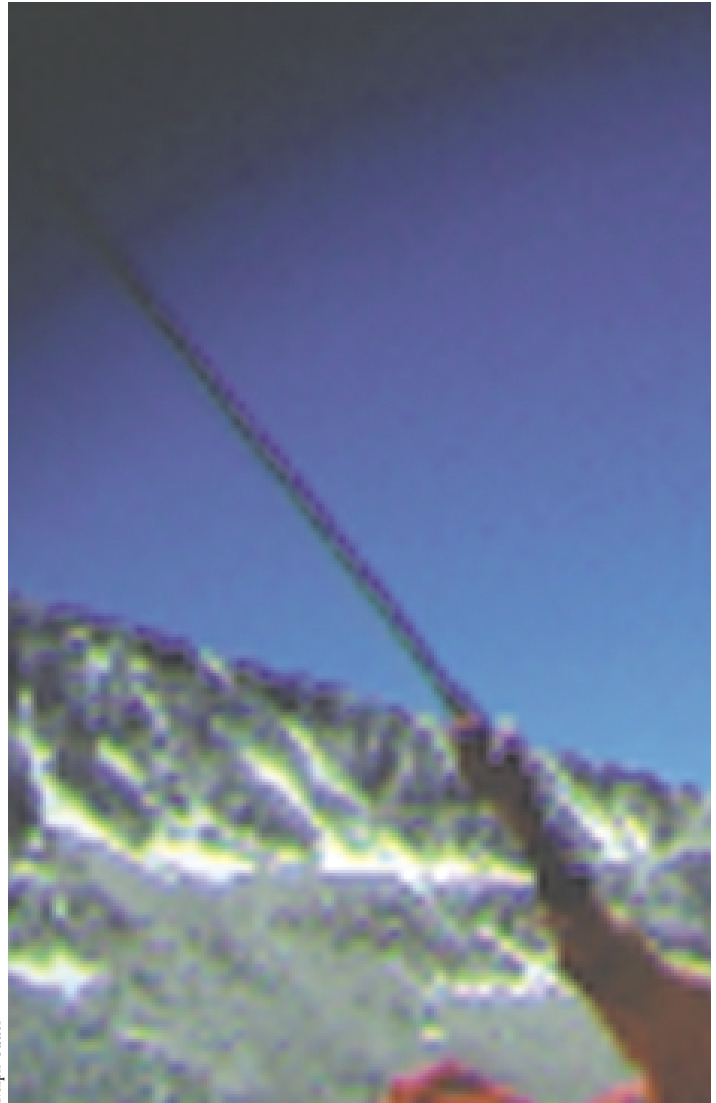
## *Are frog protection and recreational fishing compatible?*

The good news is that with some management changes we can protect native species and still provide recreational fishing opportunities. In fact, introduced trout in the high Sierra persist in Yosemite and Sequoia Kings Canyon National Parks, where stocking has been eliminated. About 40 to 50 percent of the larger lakes (greater than 2.5 acres) in these two national parks still contain trout, and many anglers continue to enjoy fishing in these waters.

Many of you, including anglers, are interested in protecting native species. In fact, some outfitters who lead fly-fishing excursions in the high Sierra now offer trips that combine fishing with field work coordinated by research scientists. This gives people an opportunity to fish and also learn about native species that live in these high elevation lakes and streams.

Federal and state resource managers are working together to protect native species while still providing quality recreational fishing in the Sierra. In order to protect native species, such as the mountain yellow-legged frog, cooperating agencies hope to develop a comprehensive conservation strategy. Using existing data and future research, we will identify and manage critical watersheds for the protection of native species.

To provide secure habitat for mountain yellow-legged frogs and other vulnerable species, stocking may be discontinued at some lakes to restore a fishless condition. We are also exploring new ways to remove fish from lakes that are critical to the survival of native frogs but now contain self-sustaining fish populations. We will continue to manage many lakes for quality recreational fishing, using stocking



Ralph Cutter

A float tube angler fishing on a high Sierra lake. Fly-fishing and catch-and-release practices are generating increased interest in backcountry angling.

as needed, taking into consideration threats to native species, restoration opportunities and angler use.

In many locations, trout are rather slow-growing, rarely exceeding 10 inches in length. Reducing the stocking frequency or the number of fingerlings stocked in these nutrient-poor lakes may produce fewer, but larger trout. The California Department of Fish and Game is using these

strategies not only to improve fisheries, but also to benefit native species by reducing the impact of introduced trout.

As we develop new strategies to manage the lakes of the Sierra Nevada region, we invite your input and feedback. Our goal is to establish a management approach that protects native species and provides quality recreation opportunities.



Ralph Cutter

Solitary figure at dawn in the high Sierra.

## *Where can I learn more about this issue?*

You can learn more about this issue, native species, resource management agencies, current resource management activities, as well as public participation and volunteer opportunities by contacting these agencies or visiting their Web sites:

### **Agencies**

USDA-Forest Service  
Pacific Southwest Region  
1323 Club Drive  
Vallejo, CA 94592  
(707) 562-9000

[www.r5.fs.fed.us](http://www.r5.fs.fed.us)

(links to Sierra Nevada Conservation Framework and PSW Research Station)

California Dept. of Fish and Game  
Fisheries Programs Branch  
1701 Nimbus Road, Suite C  
Rancho Cordova, CA 95670  
(916) 358-2845

[www.dfg.ca.gov](http://www.dfg.ca.gov)

(links to information on native species)

National Park Service  
Pacific West Region  
600 Harrison St., Suite 600  
San Francisco, CA 94107-1372

[www.nps.gov](http://www.nps.gov)

Information on the Sierra Nevada Ecosystem  
Project Report

<http://ceres.ca.gov/snep>

or

<http://alexandria.ucsb.edu/snep>



illegal transplants are costly—to you and the environment!

Collecting and moving live species from one aquatic environment to another is an illegal activity in the state of California. It can disturb or eliminate native populations, with disastrous results to the entire ecosystem.

California has stringent regulations that prohibit the planting of fish, invertebrates, or aquatic plants without a stocking permit from the California Department of Fish and Game. A state law, passed in 1998, increased the penalties for illegally planting an aquatic nuisance species to a \$50,000 fine and six months to a year in jail. Plus, violators are now financially liable for damages caused by the illegal introduction.

We need your help! Call 1-888-DFG-CALTIP (1-888-334-2258) to report violators. A reward of up to \$50,000 is available to any person who provides information or evidence leading to the arrest and conviction of a violator.





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